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Following the yellow brick road? The Euro, the Czech Republic, Hungary and Poland

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Abstract: This paper uses a combination of VAR and bootstrapping techniques to analyze whether the exchange rates of some New Member States of the EU have been used as output stabilizers (those of the Czech Republic, Hungary and Poland), during 1993-2004. This question is important because it provides a prior evaluation on the costs and benefits involved in entering the European Monetary Union (EMU). Joining the EMU is not optional for these countries but mandatory, although there is no definite deadline. Therefore, if the exchange rate works as a shock absorber, monetary independence could be retained for a longer period. Our main finding is that the exchange rate could be a stabilizing tool in Poland and the Czech Republic, although in Hungary it appears to act as a propagator of shocks. In addition, in these three countries, demand and monetary shocks account for most of the variability in both nominal and real exchange rates.

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1. Introduction

Unlike Denmark, Sweden or the United Kingdom, the adoption of the euro is not an option for the New Member States[1] (NMS) of the European Union (EU), but an obligation. However, the NMS can make decisons regarding the timing of this process. Joining the European Monetary Union (EMU) involves the loss of control over the nominal interest rate and the nominal exchange rate. At the same time, these countries will have to abide by the fiscal discipline imposed by the Maastricht convergence criteria and the Stability and Growth Pact[2]

Studies concerning the issue of the costs and benefits of joining the EMU by the NMS are normally motivated by at least one of the following complementary aspects. First, the size of the country and the state of the restructuring process from socialism to a market-oriented economy. Second, how well the business cycle synchronizes with that of the euro-zone and especially that of Germany. This issue is deep within the theory on optimum currency areas, as stated by Mundell (1961). Third, the degree to which these countries meet the requirements of the Maastricht Treaty and the Stability and Growth Pact. Finally, whether the exchange rate works as a shock absorber or if it is instead acting as a propagator of shocks.

Instead of analyzing the degree of business cycle synchronization, we will emphasize the role of the exchange rate as a shock absorber for two reasons. On the one hand, business cycles in these countries are not well synchronized with respect to those of other EU countries, and especially that of Germany (see Camacho *et al.* (2005a) and references therein, or Darvas and Szapáry (2005)). Second, although labor mobility can work as an adjustment mechanism, it has been restricted for up to 7 years. This makes labor mobility non-effective in countering asymmetric shocks (see Fidrmuc (2004)). Our findings indicate that the exchange rates have played the role of a shock absorber mainly in Poland and the Czech Republic and to a lesser extent in Hungary. Hence, these countries may find it of value to wait for a longer time before entering the EMU.

In particular, we will be deal with two main questions, namely, (*i*) whether the exchange rate has actually served as a stabilization tool in the Czech Republic, Hungary and Poland, and (*ii*) to what extent demand shocks are responsible for the real exchange rate fluctuations. Although these countries have shown little enthusiasm regarding joining the EMU (see Report 1397 of the Commission (2005)), they have been chosen on the basis that they are the biggest and most prominent new members of the EU, especially Poland.

In order to tackle these two questions we will proceed in a three-step manner. *First*, along the lines proposed by Canzoneri *et al.* (1996), we use a 2-variable SVAR that includes the relative output and nominal exchange rate to search for neutral and non-neutral shocks. For a group of EU countries, Canzoneri *et al.* (1996) found that while non-neutral shocks explain most of the variability in relative output, they explain little of the nominal exchange rate variability, where

[1] From May 1, 2004, these are Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia.

[2] Some economists have argued that Frank Baum's tale *The Wonderful Wizard of Oz* presents an allegory of the populist debate on the bimetallic monetary system that took place at the end of 19*th* century in the USA (see Rockoff (1990) or Mankiw (2001)). The populist view defended the thesis of a dual monetary standard based on gold and silver, while opponents defended the established gold standard. Dorothy was told *to follow a yellow brick road* (the gold standard), wearing a pair of silver shoes that enjoyed the power to take her home. In this paper when we ask the question whether the Czech Republic, Hungary and Poland are following the yellow brick road to the euro, we test whether the loss of monetary independence will be beneficial for them.

neutral shocks dominate. They concluded that the exchange rate was not working as a shock absorber.

Second, we apply the 3-variable SVAR suggested by Clarida and Galí (1994) to identify supply, demand and nominal shocks. Examples using a similar identification schedule are those of Canzoneri *et al.* (1996), and those of Thomas (1997), and Bjørnland (2004) for the cases of Sweden and Norway, respectively, and Borghijs and Kuijs (2004) for the cases of the Czech Republic, Hungary and Poland. Borghijs and Kuijs (2004) conclude that the exchange rates in these countries could be amplifying the effects of some shocks over output. Hence, monetary independence could be costly.

Third, in order to overcome the serious drawback of the small samples in these countries, the stationary bootstrap method of Politis and Romanos (1994) will be adapted to the SVAR. This method has been recently introduced into the econometric analysis by Camacho *et al.* (2005b) to date cyclical turning points in small samples (including the ones of the Czech Republic, Hungary and Poland). The stationary bootstrap makes it possible to numerically calculate the probability distributions of the ratio in the structural variance decomposition. This is used as an alternative method to assess the contribution of the exchange rate to stabilize output dynamics.

Our main findings are as follows: using the 2-variable SVAR, the exchange rate appears to act as a destabilizing factor in the Czech Republic and Hungary, given that output and the exchange rate are driven by different types of shocks. In Poland there is some evidence that the exchange rate can be a shock absorber. When using the 3-variable SVAR, we also find that the exchange rate is not a shock absorber in Hungary, as in the previous analysis. However, in the Czech Republic and Poland, the variance decomposition shows that the exchange rate could have been a stabilizing factor. Finally, the stationary bootstrap allows us to measure the strength to which the exchange rate works as a shock absorber. This technique shows that the exchange rates have played an important role in addressing the shocks that drive output fluctuations in the Czech Republic, Hungary and Poland for the period under consideration, 1993-2004.

The paper is organized as follows: Section 2 contains a brief sketch of the underlying theoretical model. Section 3 provides an explanation of the data employed and some preliminary tests, unit roots and structural break tests. Section 4 identifies the shocks affecting output and the nominal exchange rate, using a bivariate SVAR. Section 5 uses a 3-variable SVAR that identifies supply, demand and nominal shocks. Section 6 presents the stationary bootstrap method and its application to the models obtained in the previous sections. Section 7 summarizes all our results and compares them to those in the related literature and, finally, Section 8 presents the conclusions.

2. The model

We have borrowed the version of the Mundell-Flemming-Dornbusch model presented by Clarida and Galí (1994). In order to deal with the questions stated so far, only minor changes have been introduced into the model. We will focus on four endogenous variables: output, real exchange rate, prices and nominal exchange rate. With the exception of the interest rate, variables represent the log of home levels relative to foreign levels. The model consists in an aggregate demand function, an equation describing price-setting behavior, a demand-for-money equation and the Uncovered Interest Parity:

$$
\begin{aligned}
y_t^d &= d_t + \eta q_t - \sigma \left[i_t - E_t \left(\pi_{t+1} \right) \right], && (2.1) \\
p_t &= (1-\theta) E_{t-1} \left(p_t^e \right) + \theta p_t^e, && (2.2) \\
m_t - p_t &= y_t - \lambda i_t, && (2.3) \\
i_t &= E_t \left(s_{t+1} \right) - s_t. && (2.4)
\end{aligned}
$$

Equation (2.1) is a standard open-economy IS equation in which the demand for home output relative to foreign output, y_t^d, depends positively on the relative demand shock d_t, and the real exchange rate, $q_t = s_t - p_t$, where s_t is the nominal exchange rate and p_t is the relative price. It also depends negatively on the real interest rate differential, $i_t - E_t \left(\pi_{t+1} \right)$, where π_{t+1} is the relative rate of inflation at t. $E_t (\cdot)$ is the standard operator for conditional expectations. Equation (2.2) is the price-setting equation, where the actual price is a weighted average of the expected market-clearing price, $E_{t-1} \left(p_t^e \right)$, and the price that would actually clear the output market, p_t^e, with the superscript e denoting the long-run frictionless equilibrium level. When $\theta = 1$, prices are fully flexible. Equation (2.3) is the standard LM equation, where (relative) real money demand, $m_t - p_t$, depends positively on output and negatively on nominal interest rate. Finally, equation (2.4) is the uncovered interest parity. η, σ, θ and λ are positive parameters.

The stochastic processes that govern relative supply, y_t^s, relative money, m_t, and relative real demand shock, d_t, are given by

$$
\begin{aligned}
y_t^s &= y_{t-1}^s + \varepsilon_t^{su}, && (2.5) \\
m_t &= m_{t-1} + \varepsilon_t^n, && (2.6) \\
d_t &= -\beta \left(y_t^s - y_{t-1}^s \right) + \gamma d_{t-1} + \varepsilon_t^d. && (2.7)
\end{aligned}
$$

Output and money, (2.5) and (2.6), are pure random walks, where ε_t^{su} and ε_t^n are *i.i.d.* normal shocks. The real demand shock (2.7) is affected by three components. It negatively depends on the growth rate of output, implying that fiscal policy is counter-cyclical. At any time, there is a systematic correction from the previous period realization (γd_{t-1}, assuming that $\gamma \in (0,1)$). The economy is therefore driven by three fundamental *i.i.d.* orthogonal shocks, ε_t^{su}, ε_t^d and ε_t^n, i.e., the supply shock, the real demand shock and the nominal shock, respectively.

The long-run rational expectations equilibrium is that of a fully flexible-price ($\theta = 1$). Output is inelastically supplied and equilibrium quantities and market clearing prices are

$$
\begin{aligned}
q_t^e &= y_t^s / \eta - \xi d_t, && (2.8) \\
p_t^e &= m_t - y_t^s + \delta (1-\gamma) \lambda d_t, && (2.9) \\
s_t^e &= (1/\eta - 1) y_t^s + m_t - \delta d_t, && (2.10)
\end{aligned}
$$

where $\delta \equiv \xi \cdot [1 + \lambda (1-\gamma)]^{-1}$, and $\xi \equiv [\eta + \sigma (1-\gamma)]^{-1}$. The real exchange rate depreciates in response to a supply disturbance and appreciates in respond to a real demand disturbance, but it is left unaffected by nominal shocks in the long run. All three shocks influence the relative price and the nominal exchange rate in the long run. A positive monetary shock produces a nominal depreciation and a positive real demand shock produces a nominal appreciation. The effect of a supply shock on the nominal exchange rate is rather ambiguous. The nominal exchange rate depreciates with demand shocks. As fiscal policy is counter-cyclical, market traders anticipate a fiscal contraction in response to a supply expansion, which permits reducing the nominal interest rate.

In the short run, prices adjust sluggishly, as θ differs from 1.[3] Markets do not clear and real and nominal variables collect the impulses from the three structural shocks $\left(\varepsilon_t^{su}, \varepsilon_t^d, \varepsilon_t^n\right)$. Note that expressions (2.8) through (2.10) could be exploited for the identification of the structural shocks $\left(\varepsilon_t^{su}, \varepsilon_t^d, \varepsilon_t^n\right)$. For instance, the system (y_t, q_t, s_t), so ordered, provides a Cholesky identification for $\left(\varepsilon_t^{su}, \varepsilon_t^d, \varepsilon_t^n\right)$: in the long run, output is solely affected by the supply shock and the real exchange rate is not affected by the nominal shock. These three long-run restrictions suffice for identification. Variables are not constrained in the short run.

3. Data description, unit roots and structural break tests

We use monthly observations for Germany, the Czech Republic, Hungary and Poland, from 1993.01 to 2004.12, taken from the IMF International Financial Statistics Database (henceforth IFS) and Eurostat. The industrial production index is used as a proxy for output (line 66 at IFS), and the consumption price index as a proxy for price (line 64 at IFS). The nominal exchange rate is the bilateral euro exchange rate (Eurostat). Real exchange rates are calculated by combining the bilateral euro exchange rate and the consumer price indexes. Although most of these data are available from 1990-91, these countries went through most of their transition process from socialism to a market-oriented economy, as measured in terms of output losses, during 1990-1993 (Salvatore (2004)). This is why we prefer our sample period to start in 1993. The TRAMO-SEATS software package is used to extract the trend-cycle components of the series of output, prices and the real exchange rate (the seasonal and the irregular components are removed). All variables have been transformed into logarithms.

A variety of stationarity tests are performed to check whether the specification of equations should be written as first differences. Table 1 presents some unit root tests for the data. The results indicate that the null hypothesis of a unit root cannot be rejected for all the series against the alternative hypothesis of stationarity around a deterministic trend. Both the Augmented Dickey Fuller (ADF) and the Phillips Perron (PP) test statistics are smaller than the 10% critical value for all the series in levels. Therefore, we conclude that the series are non-stationary. To confirm that a first difference induces stationarity in these variables, test statistics for first differences are also computed. Except for the relative price in some particular cases, the test statistics are greater than their respective 10% critical values, confirming that the variables are integrated for order 1 and that a first difference suffices for stationarity. The non-stationarity of the real exchange rates implies that the PPP hypothesis does not hold, although conditions for PPP are too restrictive to be met in transition economies (Dibooglu and Kutan (2001)).

Table 1 here: Unit Roots
Figures 1-4 about here

Figures 1 through 4 show some descriptive representations. The output growth rate is represented in Figure 1. Visual inspection of the output series reveals that expansions are shorter

[3] Precise short-run solutions have not been presented in this text and are quite similar to those of Clarida and Galí (1994).

and recessions are longer for Germany than for any of these countries, especially Hungary and Poland (see Camacho *et al.* (2005b)). On the other hand, Camacho *et al.* (2005a) estimate the degree of synchronization between European economies using a variety of techniques and observations for the industrial production index. In view of their estimations, only the Hungarian cycle can be said to be well synchronized or symmetric with respect to the German business cycle (see also Csermely (2004), Fidrmuc and Korhonen (2004) and Korhonen (2003)). The evidence is unclear regarding the existence of a common business cycle between Germany and the Czech Republic or Poland. Prices are much more stable in Germany than in the three other countries (see Figure 2). These countries have experienced a considerable disinflation from values well above the 10% until values around the 5% throughout the period. Figure 3 shows the nominal rate of depreciation for the Czech Koruna, the Hungarian Forint and the Polish Zloty. The series present changes in exchange flexibility as being due to alterations in the exchange rate policy or the monetary policy framework. In particular, the first third in the series of the Czech Koruna might suggest a break in the exchange flexibility. This issue will be revisited in the next paragraph given that the validity of the analysis rests on the assumption of exchange rate flexibility. Finally, Figure 4 plots the real exchange rate. The series for the Czech Republic and Poland reflect continuous competitiveness losses, whereas the series for Hungary show a sustained real exchange rate until the middle of 1999 and later on a real depreciation of about 25%.

Some papers in the related literature argue that the length of these series should be limited to a period of homogeneous exchange rate flexibility. This is motivated by *de jure* changes in the exchange or monetary regimes (see Dibooglu and Kutan (2001), Borghijs and Kuijs (2004) or Jones and Kutan (2004)). Instead of assuming that *de jure regime* changes necessarily motivate *de facto* changes, we now test for possible structural breaks in the time series of nominal exchange rates to directly check for *de facto* changes in regime. We argue that a longer period of observations can be incorporated into the regressions, thus increasing robustness to the results. To this end, we follow the same approach to testing structural breaks as used by McConnell and Pérez-Quirós (2000) and Camacho (2004). The nominal depreciation rate is assumed to be governed by an $AR(1)$ process

$$\Delta s_t = \mu + \phi \Delta s_{t-1} + e_t. \tag{3.1}$$

If the error term e_t is normally distributed, $\sqrt{\pi/2}\,|\widehat{e}_t|$ is an unbiased estimator of the standard deviation of e_t. Then, jointly with (3.1), we estimate by GMM

$$\sqrt{\frac{\pi}{2}}\,|\widehat{e}_t| = \alpha_1 D_{1t} + \alpha_2 D_{2t} + u_t, \tag{3.2}$$

with

$$\begin{aligned} D_{1t} &= \begin{cases} 0 \text{ if } t \leq T \\ 1 \text{ if } t > T \end{cases} \\ D_{2t} &= 1 - D_{1t}, \end{aligned}$$

where T is the estimated break-point. If $\alpha_1 = \alpha_2$, the volatility of Δs_t does not suffer alterations in T. Therefore, one cannot accept a structural change at T. We use the approach suggested by Hansen (2000) for the $p-$values of the supremum tests developed in Andrews (1993) and the exponential and average tests defined in Andrews and Ploberger (1994) of the null hypothesis that $\alpha_1 = \alpha_2$. The results are shown in Table 2. The first row presents the $T-$date for which the likelihood ratio test is maximum, that is, where the probability for a structural break is the highest one. Except for the case of the Czech Republic, the $p-$values of the supremum and average tests are well above the 5% critical value. The null hypothesis of no structural change cannot be rejected for Hungary and Poland. Some possible limiting cases for the Czech Republic can be pointed out, where a definite rejection of the null hypothesis could only be done using the $p-$value of the exponential test.

Interestingly, the possible breaks identified coincide with those provided in Begg (1998), Borghijs and Kuijs (2004) or Dibooglu and Kutan (2001): the Czech Republic adopted a $\pm 7.5\%$ target zone band in February 1996. The adoption of a managed float and the exchange rate crisis, influenced by the Asian crisis, in May 1997 may also have had some influence on the turndown of the $p-$values by April 1996. As regards Hungary, on March 1995 the central parity of the Forint was realigned by 9% and a $\pm 2.25\%$ band was adopted. However, previous tests seem to be unaffected by some other alterations of monetary policy, such as the widening of the target zone bands to $\pm 15\%$ in May 2001. Finally, Poland widened the exchange rate fluctuation band to $\pm 10\%$ in February 1998, perhaps the closest monetary episode to our possibly identified structural break in April 1997, but the widening of the bands to $\pm 7\%$ in May 1995 does not seem to have influenced the results of our tests.

Summarizing, we consider it unnecessary to shorten the length of the sample on the basis of *de jure* or official changes in the exchange regime. Instead, we will follow the results from Table 2 on the basis that *de facto* changes in the exchange regime have not been observed. This strategy of sample selection allows us to use a longer period of observations, from 1993.01 to 2004.12, containing a greater number of business cycle fluctuations. Exchange rate flexibility has been the same in these three countries across this period.

Table 2 here: Structural Breaks

4. Neutral versus non-neutral shocks

This section analyzes whether the output and the nominal exchange rate are driven by shocks of the same nature. A conventional starting point is to use a bivariate VAR, containing relative output and the nominal exchange rate, as proposed by Canzoneri *et al.* (1996). Two orthogonal shocks, a non-neutral and a neutral one, are assumed to drive the economy. The model in the previous section states that long-run properties can be used as restrictions to identify these shocks. Basically, output is assumed to be exclusively led by the non-neutral shock in the long run. Canzoneri *et al.* (1996) do not clarify what neutral or non-neutral shocks really mean. A natural tentative interpretation is to map non-neutral shocks onto real shocks, that is, the supply side shock and the real demand shock. By default, the nominal shock is mapped onto the neutral one. Note, however, that the model in Section 2 cannot motivate such a recursive identification. On the other hand, the vector used could involve neglecting important information to make proper projections.

Using standard notation, the VAR model consists of $\Delta x_t = \Delta [y_t, s_t]'$, where Δx_t is a vector of stationary endogenous variables, y_t denotes the domestic output relative to German output, and s_t the nominal exchange rate of the home currency versus the euro. $\Delta \equiv (1 - L)$ is the standard first difference operator with L being the lag operator. We assume that Δx_t has a structural interpretation given by:

$$\Delta x_t = C(L)\varepsilon_t \tag{4.1}$$

where $\varepsilon_t = [\varepsilon_t^{nn}, \varepsilon_t^{n}]'$, is a vector of structural shocks. Following the terminology in Canzoneri *et al* (1996), ε_t^{nn} is interpreted as the non-neutral shock and ε_t^{n} as the neutral shock. ε_t is serially uncorrelated and $E(\varepsilon_t \varepsilon_t') = I$. $C(0)$ is a (2×2) matrix defining the contemporaneous structural relationship between the two variables in the system. Structural shocks are not observed directly. Instead, they are recovered from the moving average representation:

$$\Delta x_t = A(L)u_t \tag{4.2}$$

where u_t are non-orthogonal prediction errors, *i.e.* $E(u_t u_t) = \Sigma$, and $A(0) = I$. Equations (4.1) and (4.2) imply a linear relationship between ε_t and u_t:

$$u_t = C_0 \varepsilon_t$$

It follows that $C(L) = A(L)C_0$, and the long-run representation of (4.1) is given by $C(1) = A(1)C_0$. Now, the following long-run identifying restriction will be imposed: *the neutral shock has no long-run effect on relative output*, that is, $C_{12}(1) = 0$. This suffices for recursive identification of $[\varepsilon_t^{nn}, \varepsilon_t^{n}]'$.

The Likelihood Ratio (LR) test reveals that an order of 10 lags seems appropriate in the three cases. Table 3 shows the prediction error variance decomposition for relative output and the nominal exchange rate. Percentages refer to the fraction which can be attributed to each shock, for 1 and 48 months ahead. From this table, we highlight the following results. *First*, for the Czech Republic and Hungary, most of the variability in relative output (above 90%) can be associated with the non-neutral shock, whereas the nominal exchange rate variability is mostly determined by neutral shocks (just the reverse fraction, above 90%). Hence, for these two countries, the results suggest that the nominal exchange rate does not respond to the shocks that seem to cause the bulk of fluctuations in relative output. This gives preliminary evidence that the exchange rate does not serve as a shock absorber. *Second*, concerning Poland, the neutral shock explains about 30% of the variability in the nominal exchange rate. Compared with output variability, we find evidence that output and the exchange rate would be sharing shocks of the same nature. Something similar is found in Borghijs and Kuijs (2004).

Figure 5 plots the impulse response of the level of the variables. We can observe how real shocks account for most of the changes in relative outputs and have permanent effects for the three countries. Given the long-run restriction, the effect of nominal shocks has a smaller effect on relative outputs and tend to die out over time. On the other hand, nominal shocks lead to a long-run depreciation of the nominal exchange rate. In the case of the Czech Republic exchange rate, we obtain evidence of overshooting, provided that nominal shocks lead to an initial depreciation of the exchange rate which is subsequently reversed as the exchange rate moves downwards regarding its trend level. On the other hand, non-neutral shocks depreciate the exchange rate in the case of Hungary and Poland, but appreciate the exchange rate in the case of the Czech Republic. This is consistent with the result derived from theoretical models that the effect of a supply shock on the nominal exchange rate is ambiguous.

Finally, the estimated bivariate structure could be used to support the idea that joining the EMU is beneficial in the Czech Republic and Hungary. Monetary independence is costly as the exchange rate is buffering shocks into the domestic economy. However, a major problem with this bivariate analysis is that the economy is subject to several types of shocks. The nominal exchange rate variability can be due to demand or monetary shocks. A positive monetary shock should depreciate the nominal exchange rate and increase relative output in the short run, whereas a positive real demand shock would appreciate the nominal exchange rate and increase relative output in the short run. Therefore, a nominal depreciation can be explained by a positive monetary shock or by a negative real demand shock.

Table 3 here: Bivariate VAR
Figure 5 about here

5. Supply, demand and nominal shocks

In this Section we apply the 3-variable SVAR suggested by Clarida and Galí (1994). The vector of variables $\Delta x_t = \Delta \left[y_t, q_t, s_t\right]'$, where q_t represents the real exchange rate, now enables the identification of three shocks $\left(\varepsilon_t^{su}, \varepsilon_t^{d}, \varepsilon_t^{n}\right)$, the supply shock, the real demand shock and the nominal shock. The reduced form of the structural model can be written as:

$$\Delta x_t = A\left(L\right) C\left(0\right) \varepsilon_t = C\left(L\right) \varepsilon_t,$$

and the long-run specification is again given by $C\left(1\right) = A\left(1\right) C\left(0\right)$. According to the theoretical model, we identify the supply shock as the only one in the system which can affect output in the long run, hence $C_{12}\left(1\right) = C_{13}\left(1\right) = 0$. In the long run, nominal shocks do not affect the real exchange rate, hence $C_{23}\left(1\right) = 0$. These three restrictions allow for an exact Cholesky identification.

Using the Likelihood Ratio (LR) we conclude that 12 lags are appropriate for the Czech Republic and Poland, and 13 lags for Hungary. The variance decomposition is shown in Table 4 and Figure 6 plots the impulse-response functions, from which we highlight the following conclusions.

Supply shocks. A positive supply shock has the expected effect on output in all three countries. The impact on exchange rates is ambiguous, a result stated by the model. For instance, in the Czech Republic the nominal exchange rates have a sustained permanent appreciation in response to a positive supply shock. As relative prices sluggishly decrease, the real exchange appreciates in the short run but adjusts upward as time goes by. For Hungary and Poland, a positive supply shock makes the exchange rates depreciate. Regarding the variance decomposition analysis, the supply shock is responsible for most of output variability, mainly in Hungary (90%) and in the Czech Republic (60%). We coincide with Borghijs and Kuijs (2004) in that the supply shock has a lesser effect in Poland, where demand shocks, real plus nominal, account for around 55% of output variability. On the other hand, supply shocks are very important in explaining the real exchange rate variability in Poland (60%), in the Czech Republic (30%), and are of minor importance in Hungary (10%). A similar pattern is observed in nominal exchange rate variability.

Demand shocks. Real demand shocks have the expected impact on relative output and the exchange rate. In the Czech Republic and Poland, real appreciation is stronger than nominal appreciation. Thus, the nominal exchange rate softens the impact of the demand shock on output and competitiveness. For Hungary, where nominal appreciation is higher than real appreciation, the idea that the exchange rate is not doing the right job is strengthened (in accordance with our previous finding using the bivariate structure).

Nominal shocks. In response to a positive nominal shock, output performs in a different manner in the three countries: it has a transitory increase in the Czech Republic, it is negligible in Hungary, and it has a negative but small impact in Poland (where the nominal shock has probably not been properly identified). Real exchange rates have a temporary depreciation in the Czech Republic and Poland (*i.e.* Dornbusch's overshooting). Prices might be responding more rapidly in Hungary than in the Czech Republic or Poland in response to a positive nominal shock. As the price effect could overcome the effect from the nominal exchange rate, this makes the real exchange rates adjust downward. Hence, nominal shocks induce a real appreciation in Hungary, a further sign that the nominal exchange rate is not dampening these shocks on competitiveness. Nominal exchange rates exhibit a permanent depreciation in response to positive nominal shocks. In Hungary, a positive nominal shock has the immediate impact of a transitory appreciation.

Shock absorption. For the Czech Republic, at 6 to 12 periods ahead, output and exchange rate appear to be affected by a reasonably similar structure, which is a sign that the exchange rate has been able to soften some of the fluctuations that have affected output in the short run. This contradicts the conclusion obtained for the Czech Republic from the bivariate structure. For Hungary, whereas the supply shock explains most of the variability in relative output (about 90%), this only accounts for a small fraction in the nominal exchange rate variability (about 10%). Consequently, the exchange rate could be amplifying shocks in the Hungarian economy at any time horizon ahead. For Poland, the exchange rate seems to accommodate an important fraction of the same shocks responsible for output variability, a finding that agrees with that from the previous bivariate structure.

Real exchange rate variability. Nominal shocks account for an important fraction in the real exchange rate in the Czech Republic and Hungary, 50% and 45%, respectively, but the effect of these shocks is much smaller in Poland, 12%. This sharply contrasts with the 2-variable analysis of Dibooglu and Kutan (2001) who found that the real exchange rate variability was mainly explained by nominal shocks in Poland, whereas in Hungary most of this variability should be associated with real shocks. In the Czech Republic and Hungary, demand shocks (*i.e.* real plus nominal) amount to a total fraction of about 72% and 90%, respectively, of the real exchange rate variability. This weight is much smaller for Poland (40%). As long as these demand shocks are related to government policies, the costs of joining the EMU can be minimized in the Czech Republic and Hungary.

Table 4 here: 3-variable VAR
Figure 6 about here

6. Stationary bootstraps

The structural decompositions presented in the previous sections suffer from the unavailability of sufficiently large samples. This important drawback also affects most (if not all) of the works in the related literature: the results are not robust due to the limited size of the samples (see *inter alii* Fidrmuc and Korhonen (2004), Borghijs and Kuijs (2003) or Dibooglu and Kutan (2001)). There are two issues associated with this problem. First, statistical inference is nearly impossible due to the low number of observations. Second, the period of observation, 1993-2004, is not long enough to allow for imposing long-run structural restrictions. At best, the VAR is drawing information from a sample that only contains about three cycles, which is clearly insufficient to impose such restrictions. Camacho *et al.* (2005b) estimate that expansions last about 22 to 24 months for Germany, $30-36$ months for the Czech Republic, 44 months for Hungary and $40-41$ months for Poland. They also find that recessions last about 12 to 14 months for Germany, $12-13$ months for the Czech Republic, 8 months for Hungary and $8-9$ months for Poland (see Figure 1).

Recently, Camacho *et al.* (2005b) have adapted the stationary bootstrap method proposed by Politis and Romano (1994) to the analysis of business cycle characteristics, in order to deal with the problem of a short time series. This method consists in generating pseudo-time series that preserve the same autocorrelation structure as the original data. Random samples are generated for the time subindex t at Δx_t. Series are bootstrapped in blocks, where the first observation in each block is drawn from a discrete uniform distribution on $\{1, 2, ...T\}$, with replacement, where T is the sample size, and the block length ℓ is randomly sampled from a geometric distribution. Let t_j be the first observation of the $j-$th block, b_j, and call ℓ_j the length of block b_j. Summarizing, blocks are generated by

$$\begin{aligned} b_j &= [t_j, t_j+1, ..., t_j + \min\{T, t_j + \ell_j\}], \\ \text{where } \Pr[t = t_j] &= T^{-1}, \text{ for } t_j = 1, 2, ...T, \\ \ell_j &\sim \mathcal{G}(p), \text{ with } p \in [0,1], \\ \text{where } \Pr[\ell = \ell_j] &= \mathcal{G}(p) = (1-p)\,p^{\ell_j - 1}, \text{ for } \ell_j = 1, 2, ... \end{aligned}$$

for $j = 1, ...J$. $\mathcal{G}(p)$ is the geometric probability law. Then, blocks are stacked into a vector $B = [b_j]_{j=1}^{J}$, constrained to have a length of T. Index B reorders the original index $\{1, ...T\}$.

The bootstrapped vector is

$$[\Delta z_\tau]_{\tau=1}^{T} = \left[\Delta x_{B(\tau)}\right]_{\tau=1}^{T}.$$

Next, we calculate the SVAR decomposition from the bootstrapped vector. This process is iterated 15,000 times. Regarding parameter p at the geometric distribution, note that the mean is given by $E(\ell) = (1-p)^{-1}$, which represents the unconditional expected length of a block b_j. The sample analogue for this length is the observed mean length of expansions. We borrow from Camacho *et al.* (2005b) their calculated mean time length for expansions and adjust p accordingly: 33 months for the Czech Republic, 44 months for Hungary and 41 months for Poland.

Table 6 presents results for the bootstrapped 2-variable decomposition, for 24 periods ahead and 10 lags in all cases. Some relevant statistics are presented in the top panel of Table 6, as well as the results from the original sample. Means and medians are reasonably similar and, for the Czech Republic and Hungary, the original decompositions seem to be robust in relation to this bootstrap analysis. The bootstraps results for Poland reveal that non-neutral shocks affect output variance even more, and exchange rate variance even less, than the original sample series.

For a given time horizon ahead, call ω_{nn}^{y} the proportion of the relative output variance accounted for the non-neutral shocks, and call ω_{nn}^{s} the proportion of the nominal exchange rate variance accounted for the non-neutral shocks. Thus, let similar notations hold for the shares from the neutral shocks, *i.e.* ω_n^y and ω_n^s, such that $\omega_{nn}^{y} + \omega_n^y = 1$, and $\omega_{nn}^{s} + \omega_n^s = 1$. For example, Canzoneri *et al.* (1996) argue that the exchange rate works as a shock absorber if it addresses the shocks that lead output. This hypothesis is tested by checking whether they have *reasonably similar* ratios in the structural variance decomposition, *i.e.*

$$\omega_{nn}^{y} \approx \omega_{nn}^{s}.$$

How much distance should one *tolerate* on $(\omega_{nn}^{y} - \omega_{nn}^{s})$ to admit that the exchange rate is accommodating the shocks that affect output? The absolute value of $(\omega_{nn}^{y} - \omega_{nn}^{s})$ is constrained to the interval $[0, 1]$, from full stabilization to destabilization. Using stationary bootstraps, the lower panel of Table 6 presents a numerical computation of the probability distribution of $|\omega_{nn}^{y} - \omega_{nn}^{s}|$, for tolerance levels from 5% up to 100%, that is,

$$\Pr\left[|\omega_{nn}^{y} - \omega_{nn}^{s}| \leq \texttt{tolerance}\right]$$

For instance, the probability that ω_{nn}^{y} and ω_{nn}^{s} differ no more than 30% is 0.0044 in the Czech Republic, 0.1220 in Hungary and 0.5337 in Poland. One needs an 80% tolerance between ω_{nn}^{y} and ω_{nn}^{s} to accept, at least in half the cases, that the exchange rate is serving as a shock absorber in the Czech Republic. Such a tolerance is of about 70% in the case of Hungary, but only a 30% in Poland. Therefore, *using the 2-variable bootstrapped decomposition*, we confirm that there is evidence that the exchange rate is not a shock absorber in the Czech Republic and Hungary, but we do find evidence that it is a shock absorber in Poland.

Table 5: Bootstrapped 2-variable VAR

Notwithstanding the above, the bivariate SVAR has been criticized on the basis that it can be affected by serious misspecification biases, as the vector does not take all the relevant available information into account to make the projections. We also apply the stationary bootstraps method to the trivariate SVAR. VAR orders are 12 lags for the Czech Republic and Poland and 13 lags for Hungary. The time horizon is 12 periods ahead. Results for the bootstrapped 3-variable decomposition are presented in Tables 7 and 8. Table 7 provides descriptive statistics from the bootstraps as well as a reference line to the results from the original sample (see Table 4). We find important differences between the original and the bootstrapped decompositions. An important difference appears in the real exchange rate variability. Real demand shocks account for half the real exchange rate variability and nominal shocks account for just a quarter. Provided that these demand shocks are related to fiscal and monetary policies, the costs of joining the EMU can be controlled in these countries. Most of the variability in the real exchange rates is associated with real shocks, i.e. supply shocks plus real demand shocks. Our bootstrapped results can now be partially reconciled with those of Dibooglu and Kutan (2001): we agree that real shocks account for most of the real exchange rate fluctuations in Hungary, but we do not agree that nominal shocks account for most of the real exchange rate fluctuations in Poland. In the latter case, the divergence can be due to several issues. First, the sample of observations is different: they use monthly data from 1990:01 to 1999:03, whereas we consider the period from 1993:01 to 2004:12. Second, whereas they use a 2-variable SVAR, our conclusions are extracted from a 3-variable SVAR. As regards the real exchange rate, our findings resemble more those of Borghijs and Kuijs (2004) than those of Dibooglu and Kutan (2001). In accounting for relative output variation, the original series yields an identification for the supply shock that appears underestimated in the Czech Republic, overestimated in Hungary, whereas the results for Poland are not substantially different.

In the bootstrapped identification, the contribution of the nominal shock in explaining output variability is smaller than the original case. Nominal shocks explain about $25\% - 30\%$ in real exchange rate variances: compared to the original case, this is less in the Czech Republic and Hungary but a bit more in Poland. Real demand shocks continue to explain an important fraction of real exchange rates variability.

Next, for 12 periods ahead, call ω_j^z the proportion of variable z variability accounted by shock j, (for $z = y_t$, s_t and $j = s$, d, n (supply, real demand and nominal, respectively), such that $\sum_j \omega_j^z = 1$. Again, we wonder to what extent output and nominal exchange rate are hit by the same shocks. The first column of Table 8 gives tolerance levels varying from 5% to 100%. The remaining columns report the probability distributions of $\left|\omega_j^y - \omega_j^s\right|$ being smaller than the corresponding tolerance,

$$\Pr\left[\left|\omega_j^y - \omega_j^s\right| \leq \texttt{tolerance}\right],$$

for $j = su$, d, n. For example, in the Czech Republic the probability that ω_{su}^y diverges from ω_{su}^s by no more than 30% is 0.206. Provided that this probability is quite low, this indicates that the supply shock does not affect output and the nominal exchange rate in a similar manner. We conclude that the exchange rate is not very helpful in smoothing the supply fluctuations. However, provided that the difference $|\omega_d^y - \omega_d^s|$ being smaller than 35% is observed 70% of times, and the difference $|\omega_n^y - \omega_n^s|$ being smaller than 35% is observed 60% of times, we conclude that the exchange rate might be a useful tool in the absorption of both the real demand and the nominal demand shock.

For Hungary, although there is little evidence that the exchange rate is accommodating real shocks, there appear some signs that the exchange rate could be strongly used for addressing nominal shocks. For Poland, we again find evidence that the exchange rate works as an important stabilization tool. In fact, the difference $|\omega_n^y - \omega_n^s|$ being smaller than 20% is observed 50% of times.

Tables 6 and 7 here: Bootstrapped 3-variable VAR

7. Summary of results and implications

This Section combines the results obtained in previous Sections with those from the related literature and the Convergence Report 2004 (European Central Bank (2004)) in order to evaluate how well prepared these countries are to adopt the Euro.

The Convergence Report 2004 examines the state of economic convergence of New Member States. Over the past 2 years, harmonized inflation in the three countries has been relatively low. Over the reference period used in the Convergence Report 2004 (from September 2003 to August 2004), the reference value for inflation was 2.4%. Only the Czech Republic had a harmonized inflation rate below that reference value (1.8%), whereas Poland was slightly above it (2.5%). Hungary was considerably above the reference value (6.5%). However, since around mid-2003, there has been a rising trend in inflation rates in the three countries (see Figure 2).

In July 2004, the Council viewed deficits ratios in these countries as excessive and issued a recommendation to each of them. Different deadlines, from 2005 to 2008, were set for their correction, taking into account the level of the deficit, growth prospects and the intentions of the authorities regarding participation in the EMU. In December 2004, the Commission considered that the Czech Republic and Poland had taken effective action in response to the Council recommendation, in particular with respect to the 2005 deficit target set in the May 2004 convergence programs, but not for Hungary. The three countries exhibited debt ratios below the 60% reference value. However, the debt ratio increased substantially in the Czech Republic and Poland, whereas in Hungary this wanders around the very limit.

In 2001 and 2002, long-term interest rates were on a broad downward trend in the three countries, moving towards the euro area level. However, during 2003, this trend reversed and the long-run interest rate started to diverge. The increase in long-term interest rates was due to increasing inflationary pressures and fiscal uncertainty. With a reference value of 6.4%, in the Czech Republic, the long-term interest rate is below the reference value (4.7%), whereas in Poland this is very close to the reference value (6.9%). In Hungary, the long-term interest rate is well above (8.1%).

Finally, none of the countries participated in ERM II during the last 2 years. According to the Convergence Report 2004, the exchange rates exhibit a high degree of volatility partly related to uncertainties regarding the outlook for fiscal policy.

Another important point is the level of synchrony of the business cycle. The Czech Republic presents a business cycle dominated by asymmetric shocks (see Camacho *et al.* (2005a), Darvas and Szapáry (2005) or Fidrmuc and Korhonen (2004)). The use of VAR techniques has not yielded conclusive results. The bivariate VAR from Section 4 as well as the bootstrapped one from Section 6 indicate that the exchange rate is not probably doing the right job. The trivariate analysis shows that the exchange rate might be addressing the bulk of the fluctuations that govern output, especially those coming from the demand side of the economy. Real demand shocks account for half the fluctuations in the real exchange rate. As long as these shocks are related to controllable demand policies, this indicates that adoption of the euro would not be very costly. A fraction of about 3/4 of output fluctuations are due to supply shocks, whereas nominal shocks do not seem to cause serious output destabilization. Therefore, as a monetary union implies that these nominal shocks would disappear, joining the EMU should not raise much fear of losing monetary independence.

Hungarian cycles are well synchronized with respect to those of the euro-zone and that of Germany (see Camacho *et al.* (2005a), Darvas and Szapáry (2005), Csermely (2004), Fidrmuc and Korhonen (2004) or Korhonen (2003)). On the other hand, both the 2- and the 3-variable SVAR suggest that the exchange rate behaves as a propagator rather than an absorber of shocks. Application of the bootstrapped techniques corroborate these findings. In addition, as nominal shocks seem to be producing the large bulk of the fluctuations in the real exchange rate, we find that the nominal exchange rate has been strongly addressing these sort of shocks on output. Given that most of the nominal shocks would vanish under a monetary union and provided that real demand shocks help to explain about 60% of the real exchange rate, these results indicate that joining the EMU could not be very costly for Hungary. In contrast, Jones and Kutan (2004) have found that the Hungarian economy is highly sensitive to shifts in German monetary policy, a finding that would lead to recommending maintaining some degree of monetary independence for some time.

Poland is the biggest country among the new Member States. Evidence is unclear regarding whether its business cycle moves like those of euro-zone countries (see Camacho *et al.* (2005a) or Darvas and Szapáry (2005)). Throughout all our estimations, the nominal exchange rate has been found to address a considerable fraction of those shocks driving the output. Supply shocks have a lower effect on output in Poland, where demand shocks (real and nominal) account for around 55% of output variability. Real demand shocks explain about 30-40% of movements in the real exchange rate, whereas this fraction is 11-23% for nominal shocks. Borowski (2004), considering a wider variety of *pros* and *cons* regarding joining the EMU, concludes that adoption of the euro in Poland is likely to be beneficial. The exchange rate is, however, viewed as a source of shocks and a destabilizing factor (see also the report of the National Bank of Poland (2004)). In contrast, based on our results, we conclude that the exchange rate has been doing the right job in Poland.

Table 9 groups all these results together. In the sub-panel labelled "Number of convergence criteria (out of 5)", we group the number of convergence criteria met by each country. Thus, the Czech Republic is the closest to the Maastricht criteria, whereas Hungary is furthest. The general impression is that exchange rate flexibility has been wisely used to accommodate domestic imbalances.

Table 8 here: Summary of results

8. Conclusions

In this paper we use the SVAR approach to study the possible gains from joining the European Monetary Union for the Czech Republic, Hungary and Poland, focusing on the role of the exchange rate as a shock absorber. An important caveat has to be borne in mind when assessing such results obtained from SVAR techniques and those coming from previous and subsequent literature: these analyses are based on the imposition of long-run restrictions on the structural representation while using samples of limited size. This casts considerable doubt on the robustness of the results. In an attempt to overcome the important drawback of small samples, we have proposed an alternative criterion that helps to quantify how weak or strong the degree of shock absorption is, based on stationary bootstraps.

Our bootstrapped analysis shows that exchange rates have been used as a shock absorber during the period under consideration 1993-2004, mainly in Poland and the Czech Republic, and to a lesser extent in Hungary. Although this result is more evident in Poland than in the Czech Republic or Hungary, the techniques applied here have revealed that in these two last cases the exchange rates have been accommodating shocks coming from the demand side of the economy. These countries may find it of value to wait for a longer period before entering the EMU.

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Table 1: Testing for unit roots

	Czech Republic		Hungary		Poland	
Variable	**ADF**	**PP**	**ADF**	**PP**	**ADF**	**PP**
y_t	0,05	0,13	-1,02	-1,54	-2,48	-2,10
Δy_t	-2,68 *	-2,68 *	-4,4 ***	-4,07 ***	-3,14 **	-4,56 ***
s_t	-1,70	-2,74	-1,01	-0,80	-2,47	-2,24
Δs_t	-9,81 ***	-10,26 ***	-7,75 ***	-7,90 ***	-7,99 ***	-7,79 ***
q_t	-2,59	-2,74	-2,93	-2,33	-2,20	-1,77
Δq_t	-10,36 ***	-10,26 ***	-9,08 ***	-8,76 ***	-8,23 ***	-7,83 ***
p_t	-0,11	-0,16	-0,91	0,04	-3,06	-4,45
Δp_t	-3,04 **	-7,61 ***	-1,52	-2,66 *	-1,87	-3,79 ***

The number of lags used in the ADF test is determined by selecting the highest lag with a significant t-value on the last lag. A constant and a time trend are included in the regression for levels. A constant is included when testing for first differences. Critical values (1%, 5% and 10%) are taken from MacKinnon (1996): Dickey-Fuller and Phillips-Perron without trend (-3.47, -2.88, -2.57). Dickey-Fuller and Phillips-Perron with trend (-4.02, -3.44, -3.14).
*: Rejection of the unit root hypothesis at the 10% level.
** :Rejection of the unit root hypothesis at the 5% level.
***: Rejection of the unit root hypothesis at the 1% level.

Table 2: Testing for possible structural breaks

	Czech	**Hungary**	**Poland**
Possible break	1996 April	1995 May	1997 April
***p*-supremum**	0,066	0,900	0,309
***p*-exponential**	0,033	0,670	0,175
***p*-average**	0,080	0,640	0,168

Table 3: Bivariate SVAR

		Output		Nominal Exchange Rate	
Country	Horizon	Non-Neutral	Neutral	Non-Neutral	Neutral
Czech Rep.	1	97,99%	2,01%	11,22%	88,78%
	48	93,92%	6,08%	12,96%	87,04%
Hungary	1	91,80%	8,20%	6,98%	93,02%
	48	87,62%	12,38%	15,85%	84,15%
Poland	1	31,68%	68,32%	67,79%	32,21%
	48	47,55%	52,45%	69,08%	30,92%

Table 4: Trivariate SVAR

	Czech Republic (VAR(12))								
	Output			Real Exchange Rate			Nominal Exchange Rate		
Horizon	**Supply**	**Demand**	**Nominal**	**Supply**	**Demand**	**Nominal**	**Supply**	**Demand**	**Nominal**
1	46,8%	21,1%	32,1%	27,3%	19,4%	53,4%	55,1%	2,1%	42,9%
6	45,7%	19,7%	34,6%	26,9%	19,4%	53,8%	52,2%	4,7%	43,1%
8	50,7%	18,6%	30,7%	25,2%	23,0%	51,8%	49,4%	6,5%	44,2%
12	59,2%	15,5%	25,3%	27,5%	20,4%	52,1%	48,2%	6,9%	44,9%
24	60,9%	13,4%	25,6%	27,9%	23,1%	49,1%	47,3%	7,2%	45,5%
36	61,7%	13,1%	25,1%	28,0%	24,3%	47,7%	47,2%	7,4%	45,4%
48	62,1%	13,0%	24,9%	27,8%	25,2%	47,0%	47,1%	7,6%	45,3%

	Hungary (VAR(13))								
	Output			Real Exchange Rate			Nominal Exchange Rate		
Horizon	**Supply**	**Demand**	**Nominal**	**Supply**	**Demand**	**Nominal**	**Supply**	**Demand**	**Nominal**
1	90,98%	8,03%	0,99%	0,72%	50,95%	48,33%	2,15%	80,81%	17,03%
6	95,16%	4,27%	0,57%	4,81%	52,20%	42,99%	10,51%	71,56%	17,93%
8	95,64%	3,83%	0,54%	5,06%	52,13%	42,80%	11,66%	71,54%	16,79%
12	94,12%	4,61%	1,27%	7,61%	49,48%	42,92%	13,47%	66,42%	20,11%
24	92,13%	5,67%	2,20%	9,37%	45,91%	44,72%	13,52%	65,35%	21,13%
36	91,75%	5,88%	2,37%	9,49%	44,35%	46,17%	13,83%	64,66%	21,50%
48	91,66%	5,89%	2,45%	9,50%	43,31%	47,19%	13,97%	64,36%	21,67%

	Poland (VAR(12))								
	Output			Real Exchange Rate			Nominal Exchange Rate		
Horizon	**Supply**	**Demand**	**Nominal**	**Supply**	**Demand**	**Nominal**	**Supply**	**Demand**	**Nominal**
1	30,9%	12,1%	57,0%	60,2%	35,0%	4,8%	68,3%	15,0%	16,8%
6	40,5%	15,7%	43,8%	64,3%	27,6%	8,1%	70,8%	12,4%	16,8%
8	41,7%	15,5%	42,8%	63,2%	26,8%	10,0%	70,2%	12,3%	17,5%
12	45,8%	18,1%	36,1%	61,3%	27,4%	11,2%	68,4%	13,8%	17,8%
24	44,8%	16,7%	38,5%	59,3%	28,8%	11,9%	66,2%	15,0%	18,8%
36	44,9%	16,8%	38,4%	58,8%	28,6%	12,6%	66,1%	15,0%	18,9%
48	44,9%	16,8%	38,3%	58,7%	28,6%	12,7%	66,0%	15,0%	18,9%

Table 5: Bootstrapped bivariate VAR

	Czech		Hungary		Poland	
	ω_{nn}^{y}	ω_{nn}^{s}	ω_{nn}^{y}	ω_{nn}^{s}	ω_{nn}^{y}	ω_{nn}^{s}
Mean	92,8%	15,1%	83,3%	24,6%	75,0%	48,6%
Median	94,4%	13,4%	87,5%	20,6%	76,0%	49,6%
Original case	93,9%	12,9%	90,0%	16,4%	47,3%	70,6%
Maximum	99,8%	59,1%	99,5%	95,0%	99,1%	90,2%
Minimum	37,2%	1,5%	7,6%	2,3%	25,2%	4,4%
Std. Dev.	0,056	0,076	0,130	0,147	0,120	0,153
Tolerance	$\lvert\omega_{nn}^{y}-\omega_{nn}^{s}\rvert$		$\lvert\omega_{nn}^{y}-\omega_{nn}^{s}\rvert$		$\lvert\omega_{nn}^{y}-\omega_{nn}^{s}\rvert$	
5%	0,0003		0,0187		0,0984	
10%	0,0005		0,0367		0,1973	
15%	0,0008		0,0545		0,2934	
20%	0,0013		0,0757		0,3817	
25%	0,0027		0,0986		0,4573	
30%	0,0044		0,1220		**0,5337**	
35%	0,0071		0,1521		0,6071	
40%	0,0113		0,1818		0,6761	
45%	0,0189		0,2188		0,7383	
50%	0,0311		0,2607		0,7974	
55%	0,0497		0,3148		0,8397	
60%	0,0817		0,3784		0,8837	
65%	0,1301		0,4557		0,9205	
70%	0,2058		**0,5541**		0,9510	
75%	0,3179		0,6781		0,9735	
80%	0,4894		0,8135		0,9906	
85%	**0,7151**		0,9318		0,9979	
90%	0,9287		0,9933		0,9999	
95%	0,9987		1,0000		1,0000	
100%	1,0000		1,0000		1,0000	

Bivariate vector is bootstrapped with 15000 replications. Shares refer to a 24 periods ahead horizon. VAR order is 10 lags in all of the cases.

Table 6: Bootstrapped trivariate VAR (variance decomposition)

Czech Republic

	Output			Real Exchange Rate			Nominal Exchange Rate		
	Supply	Demand	Nominal	Supply	Demand	Nominal	Supply	Demand	Nominal
Mean	73,2%	9,5%	17,4%	16,9%	51,5%	31,6%	22,8%	34,0%	43,2%
Median	77,6%	6,7%	13,7%	15,2%	52,2%	29,4%	20,5%	30,0%	43,9%
Original case	59,2%	15,5%	25,3%	27,5%	20,4%	52,1%	48,2%	6,9%	44,9%
Maximum	98,2%	85,1%	89,3%	71,4%	91,9%	82,6%	73,6%	91,0%	89,7%
Minimum	1,7%	0,2%	0,3%	1,4%	5,2%	2,0%	1,3%	1,9%	1,2%
Std. Dev.	0,17	0,09	0,14	0,09	0,17	0,16	0,12	0,19	0,19

Hungary

	Output			Real Exchange Rate			Nominal Exchange Rate		
	Supply	Demand	Nominal	Supply	Demand	Nominal	Supply	Demand	Nominal
Mean	67,3%	13,5%	19,2%	17,7%	58,4%	23,9%	23,3%	54,7%	22,0%
Median	72,3%	9,7%	13,7%	15,4%	61,7%	19,6%	20,5%	57,9%	18,3%
Original case	94,12%	4,61%	1,27%	7,61%	49,48%	42,92%	13,47%	66,42%	20,11%
Maximum	97,7%	87,8%	92,4%	78,8%	92,1%	83,2%	81,9%	92,7%	87,3%
Minimum	1,3%	0,4%	0,2%	2,1%	4,9%	2,1%	2,2%	3,5%	2,0%
Std. Dev.	0,20	0,11	0,16	0,10	0,17	0,15	0,13	0,17	0,14

Poland

	Output			Real Exchange Rate			Nominal Exchange Rate		
	Supply	Demand	Nominal	Supply	Demand	Nominal	Supply	Demand	Nominal
Mean	50,1%	24,4%	25,5%	35,0%	41,2%	23,8%	35,7%	33,1%	31,2%
Median	52,8%	18,1%	21,6%	32,9%	38,6%	17,7%	33,8%	28,7%	27,4%
Original case	45,8%	18,1%	36,1%	61,3%	27,4%	11,2%	68,4%	13,8%	17,8%
Maximum	96,9%	91,2%	91,2%	84,5%	89,7%	84,0%	86,9%	90,7%	91,5%
Minimum	1,1%	0,4%	1,0%	1,5%	3,0%	0,9%	2,1%	1,7%	1,9%
Std. Dev.	0,23	0,19	0,17	0,18	0,21	0,17	0,18	0,19	0,18

Trivariate vector is bootstrapped with 15000 replications. Shares refer to 12 periods ahead. VAR order is 12 lags for the Czech Republic and Poland, and 13 for Hungary.

Table 7: Distribution of distances

	Czech Republic			Hungary			Poland		
Tolerance	$\lvert\omega_s^y-\omega_s^s\rvert$	$\lvert\omega_d^y-\omega_d^s\rvert$	$\lvert\omega_n^y-\omega_n^s\rvert$	$\lvert\omega_s^y-\omega_s^s\rvert$	$\lvert\omega_d^y-\omega_d^s\rvert$	$\lvert\omega_n^y-\omega_n^s\rvert$	$\lvert\omega_s^y-\omega_s^s\rvert$	$\lvert\omega_d^y-\omega_d^s\rvert$	$\lvert\omega_n^y-\omega_n^s\rvert$
5%	0,027	0,097	0,085	0,038	0,036	0,183	0,153	0,126	0,144
10%	0,055	0,221	0,172	0,081	0,075	0,369	0,288	0,234	0,285
15%	0,087	0,349	0,265	0,128	0,114	**0,534**	0,408	0,333	0,417
20%	0,126	0,457	0,352	0,176	0,155	0,660	**0,509**	0,424	**0,534**
25%	0,162	**0,549**	0,432	0,223	0,205	0,748	0,599	**0,509**	0,633
30%	0,206	0,629	**0,507**	0,271	0,259	0,810	0,679	0,586	0,717
35%	0,252	0,699	0,578	0,321	0,326	0,861	0,743	0,664	0,788
40%	0,305	0,759	0,653	0,374	0,399	0,898	0,796	0,737	0,848
45%	0,367	0,815	0,722	0,433	**0,481**	0,929	0,845	0,801	0,897
50%	0,430	0,862	0,782	**0,500**	0,569	0,953	0,887	0,860	0,936
55%	**0,502**	0,903	0,838	0,569	0,667	0,971	0,921	0,912	0,967
60%	0,583	0,940	0,890	0,641	0,768	0,985	0,949	0,950	0,986
65%	0,666	0,965	0,932	0,720	0,864	0,993	0,970	0,977	0,995
70%	0,758	0,983	0,968	0,801	0,940	0,998	0,985	0,993	0,998
75%	0,853	0,994	0,989	0,881	0,983	0,999	0,994	0,998	1,000
80%	0,934	0,999	0,998	0,945	0,998	1,000	0,999	1,000	1,000
85%	0,983	1,000	1,000	0,989	1,000	1,000	1,000	1,000	1,000
90%	0,998	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
95%	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
100%	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000

Table 8: Summary of results

	Czech Republic	Hungary	Poland
Symmetry versus Germany [a]	No	Yes	No
Maastricht Criteria:			
Government deficit over GDP [b]	-12,60%	-6,20%	-3,90%
Government debt over GDP [c]	37,80%	59,10%	45,40%
Inflation [d]	1,80%	6,50%	2,50%
Long run interest rates [e]	4,70%	8,10%	6,90%
ERM II participation	No	No	No
Number of convergence criteria (out of 5)			
2002	3	1	2
2003	3	1	3
2004	3	1	1
Is the exchange rate a shock absorber?	Maybe	No	Yes

a: This criterion is borrowed from Camacho *et alii* (2005a).
b: Reference value is 3%. Data refer to 2003.
c: Reference value is 60%. Data refer to 2003.
d: Reference value is 2,4%, from September 2003 to August 2004.
e: Reference value is 6,4%, from September 2003 to August 2004.

Figure 1: Output growth

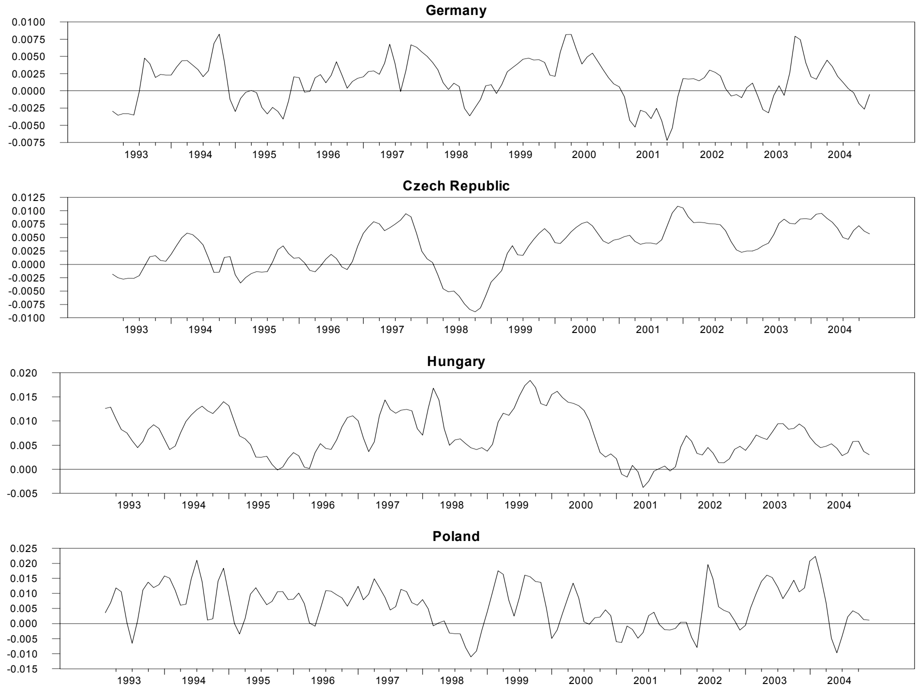

Figure 2: Annual inflation

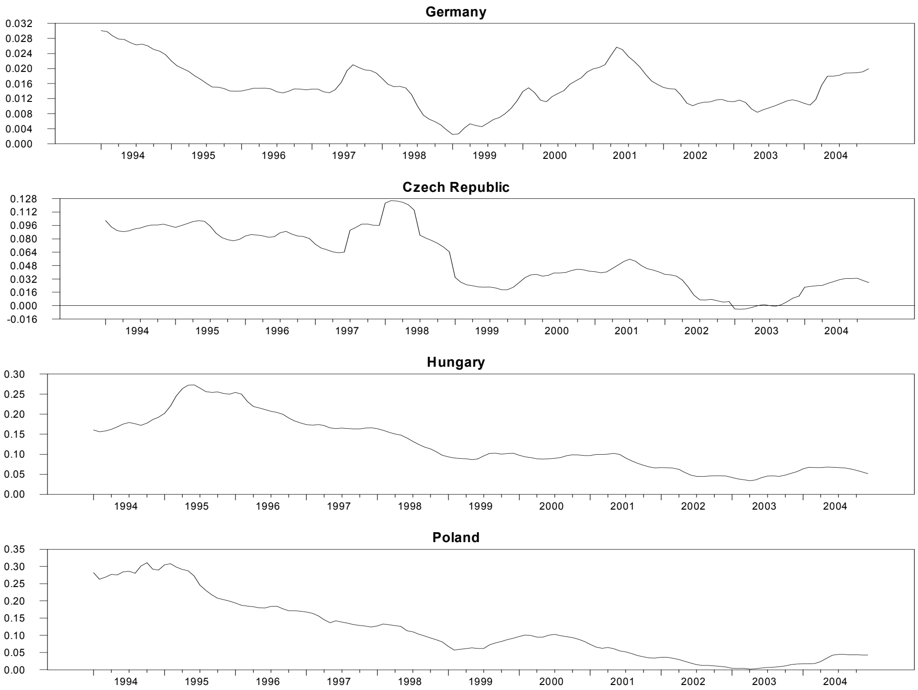

Figure 3: Nominal depreciation rate

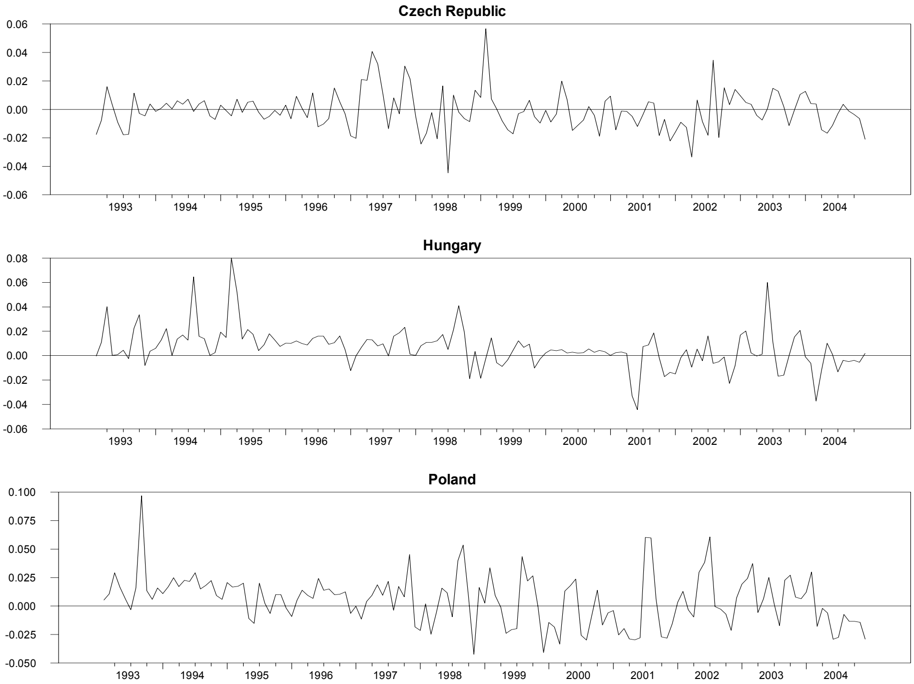

Figure 4: Real exchange rate

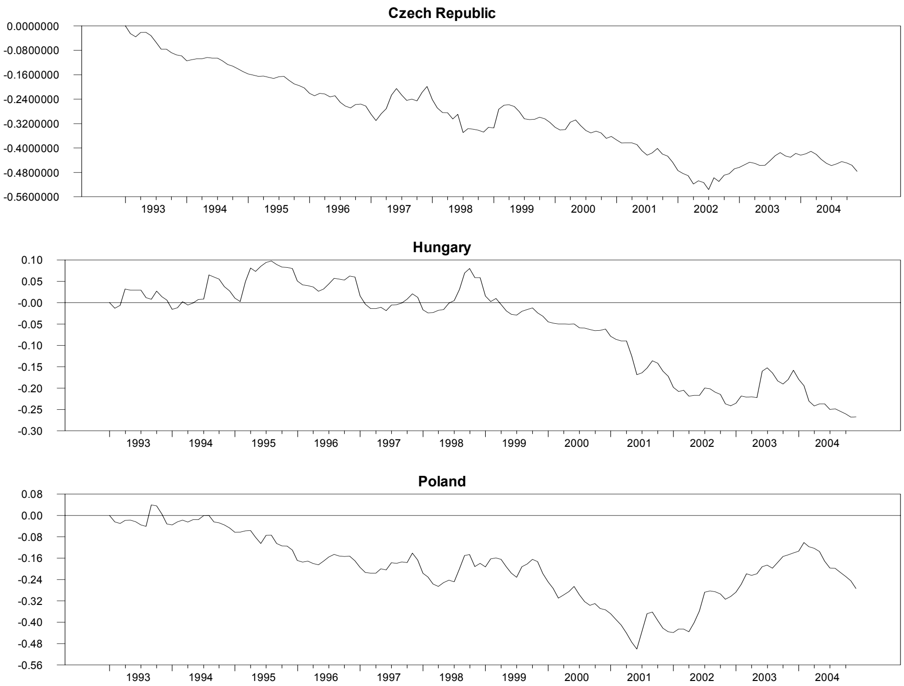

Figure 5: Non-neutral versus neutral shocks

Impulse-responses from 2-variables SVAR

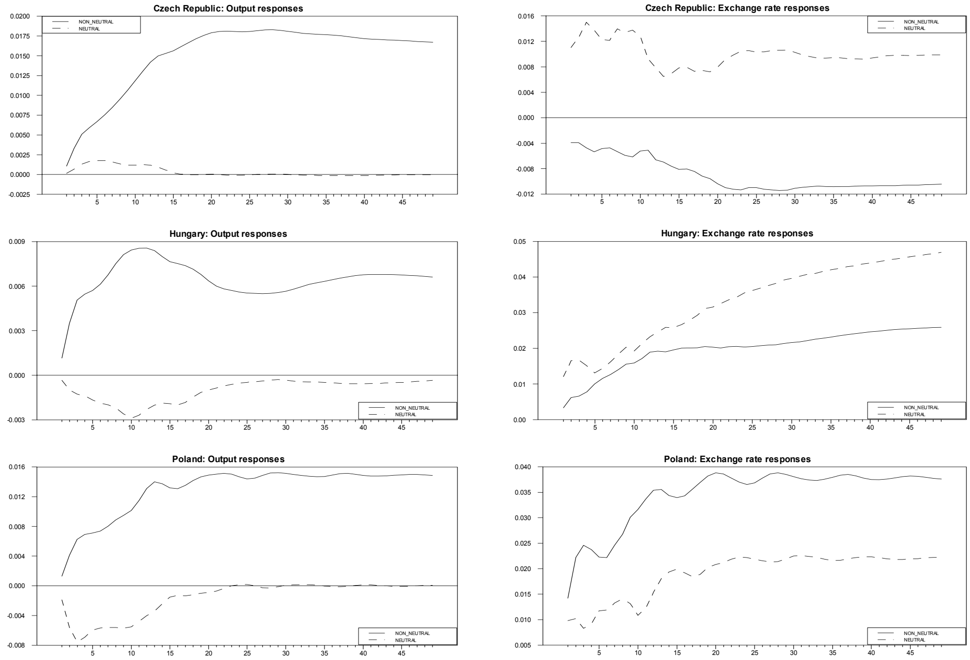

Figure 6: Supply, real demand and nominal shocks

Impulse-responses from 3-variables SVAR